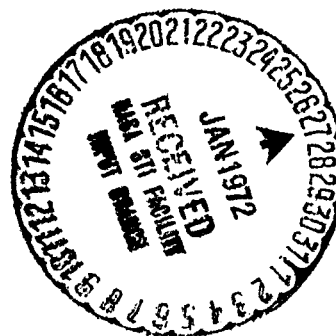


X  
NASA CR-122328

***BOEING***



N72-14465 (NASA-CR-122328) FABRICATION OF THE  
TITANIUM TRANSITION RING OF THE LARGE  
SPACE TELESCOPE (LST) Final Report L.A.  
Unclas Klein (Boeing Co.) Dec. 1971 11 p  
12347 CSCL 14B

G3/14

FACIL

(NASA CR OR TMX OR AD NUMBER)

(CATEGORY)

FINAL REPORT  
FOR  
FABRICATION OF THE TITANIUM TRANSITION RING ASSEMBLY  
OF THE LARGE SPACE TELESCOPE (LST)

Contract No. NAS5-11451

December 1971

Prepared For:

Goddard Space Flight Center  
Greenbelt, Maryland

By

The Boeing Company  
Aerospace Group  
Research and Engineering Division  
Seattle, Washington

Prepared by

*Leo A. Klein*  
Leo A. Klein  
Technical Leader

Approved by

*E. F. Styer*  
E. F. Styer  
LST Program Manager



## 1.0 Introduction

This document is the final report of The Boeing Company's activity in fabricating the titanium Transition Ring Assembly of the Large Space Telescope (LST). This report summarizes the chronology of fabrication effort involved in accomplishing this activity.

## 2.0 Background

The Transition Ring Assembly consists of two large titanium rings which are bolted together to form a structural box-shape of about 11 feet in diameter. The gross cross section dimensions of the assembly are 13 inches wide by 7 inches thick. The function of the ring assembly is to structurally connect the major equipment elements of the LST telescope vehicle together, and to form the interface attachment to the Shuttle or Titan space transportation vehicle in transporting the telescope vehicle into orbit. Goddard drawings were used as the engineering instructions in accomplishing the fabrication tasks. These drawings are:

- (a) Transition Ring Assembly - GE 1297296
- (b) Transition Ring - GE 1297297
- (c) Adapter and Staging Ring - GE 1297298

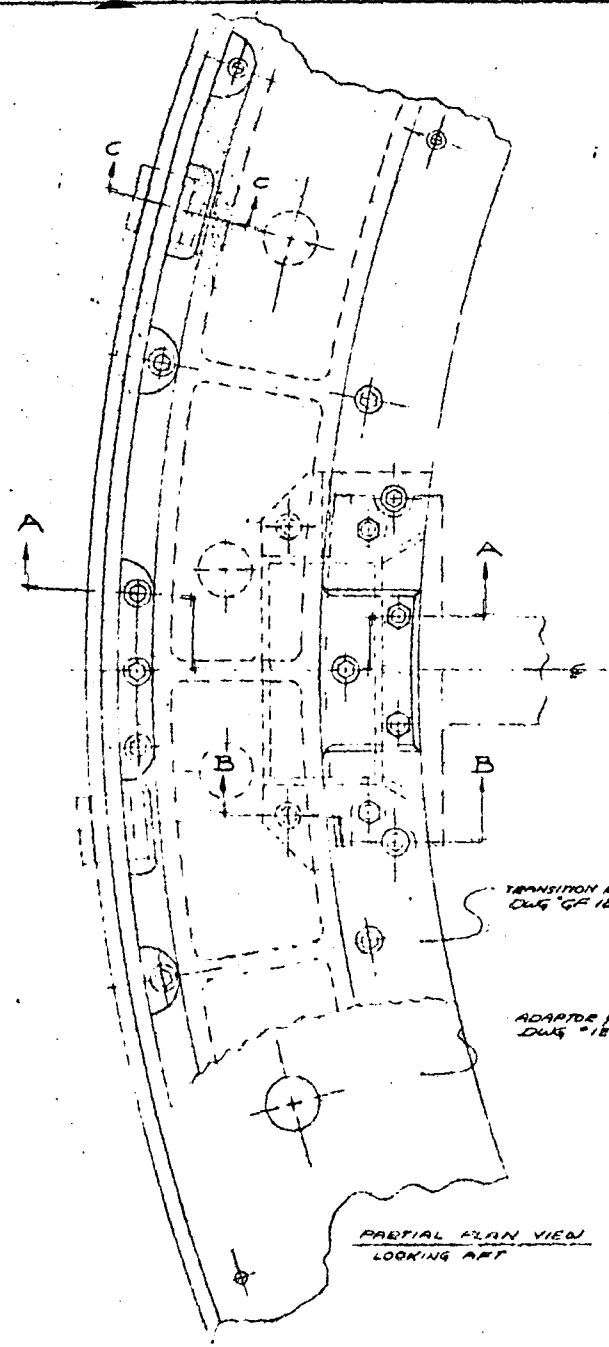
Reduced copies of these drawings are shown on pages 3, 4 and 5.

## 3.0 Discussion

The fabrication process was divided into seven basic tasks. These tasks were Transition Ring Fabrication, Adapter and Staging Ring Fabrication, Fastener Procurement, Hole Transfer Templates Fabrication, Assembly and Packaging/Shipment. A summary of each of these tasks is described in the following material.

REV. 1-1-71	
A	ADDED (2) 3/8 DIA BOLTS CHANGED (2) 1/2 DIA BOLTS TO 3/8 DIA
1/1	1/1

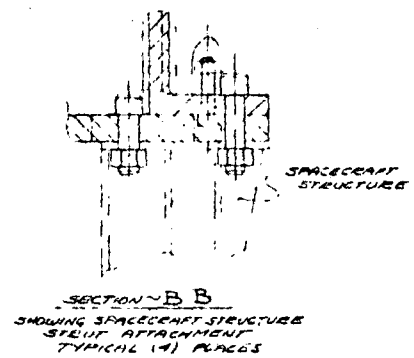
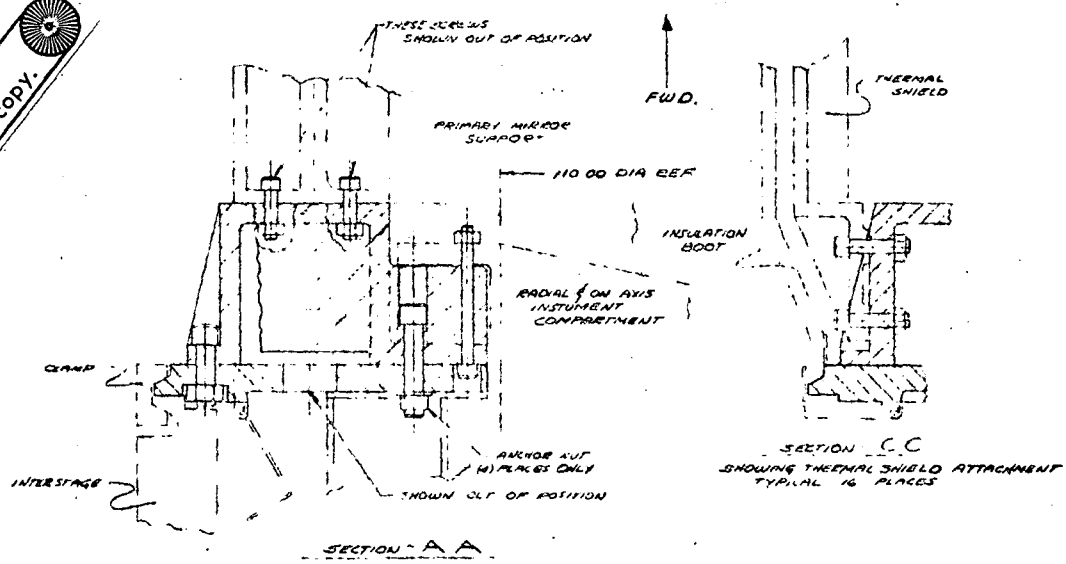
Reproduced from  
best available copy.



TRANSITION RING  
Dwg #GF 1297297

ADAPTER & STRAINING RING  
Dwg #1297298

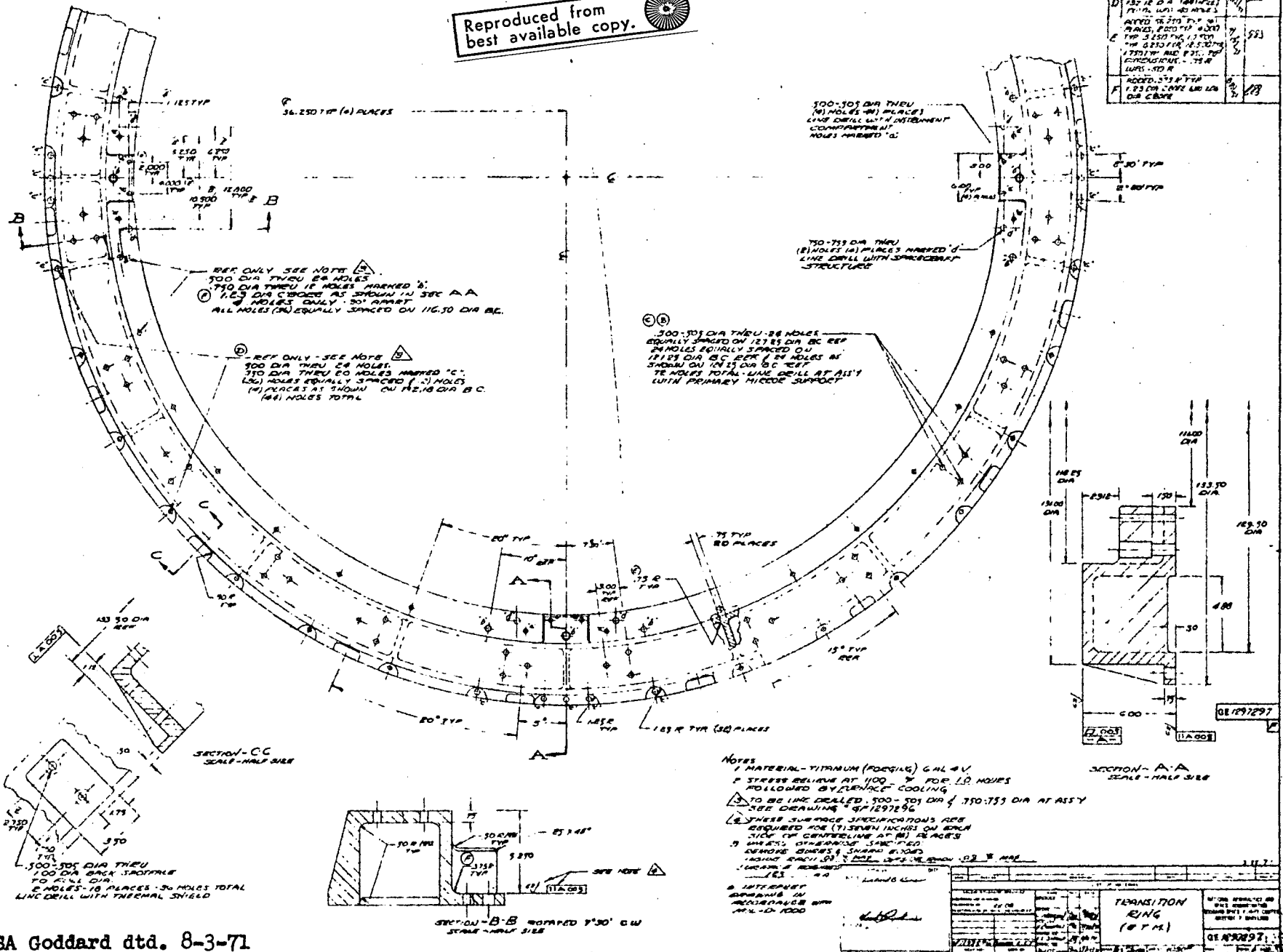
PARTIAL PLAN VIEW  
LOOKING AFT



SECTION C-C  
SHOWING THERMAL SHIELD ATTACHMENT  
TYPICAL 16 PLACES

GF/297296

TRANSITION RING ASSEMBLY	
DATE: 1-1-71	BY: [Signature]
DESIGNED BY: [Signature]	CHECKED BY: [Signature]
APPROVED BY: [Signature]	DATE: 1-1-71
PROJECT: [Blank]	REVISION: 1
SCALE: 1/2" = 1"	QUANTITY: 1
DATE: 1-1-71	BY: [Signature]





### 3.1 Transition Ring (GE 1297297)

This ring was made from a 6Al-4V titanium forging. The forging was manufactured under subcontract by the Ladish Company of Cudahy, Wisconsin. This forging was the largest size titanium forging ever produced. The forging process started with a 27" diameter titanium billet weighing 7,700 pounds and when completed by Ladish the forging weighed 6,000 pounds. The Ladish Company annealed and rough machined the forging to dimensions 135 inches outer diameter, 109 inches inner diameter and 8-1/2 inches thick.

The Boeing Company at Seattle, Washington, then machined the forging to shape which involved some rather intricate sculpturing to form the hollowed-out hat cross-section configuration. All 1/2 and 3/4 inch holes in the forging which interface the Transition Ring Assembly with other elements of the telescope vehicle were drilled at this time 1/8 inch undersize. The reason for the undersize was to allow this Transition Ring Assembly, when mated with the other telescope vehicle elements, to be line drilled to a hole tolerance of  $\pm .005$  inches.

### 3.2 Adapter and Staging Ring (GE 1297298)

This task involved the fabrication of a flat approximately 10 foot diameter ring from titanium plate material. This ring, when mated with the transition ring described in Section 3.1, forms a part of closed box cross-section. Two different courses were followed in obtaining the plate material for fabricating the ring. Initially an order was placed with the Titanium Metals Corporation of America (TMCA) to provide to Boeing four ring segments 1.75 inch thick. These segments were then to be welded together by Boeing thereby forming the basic ring which would then be machined to shape. However,

prior to delivery to Boeing of these segments a redirection of this plate order was received from Goddard. This redirection substituted GFE plate material from the cancelled SST Program for the plate material which Boeing had initiated procurement with TMCA. The GFE material consisted of several plates of titanium 1.8 x 17 x 288 inches. Because of the status at the time of the redirection the 1.75 inch plate had been fabricated by TMCA, but the four segments had not yet been cut. This plate was then delivered to Goddard for another application.

Because of the narrower SST material, nine segments were required to make the basic ring. The ends of each segment were machined providing for hand weld fillets. The segments were carefully hand welded together to insure flatness of the assembled ring. Approximately 25 pounds of titanium was used in the welding process. The welds were X-rayed and the ring then stress-relieved. The ring was machined to within approximately 1/8 inch of the final dimensions when buckling occurred in the inner diameter. This warpage indicated that the ring was not in a fully stress-relieved condition. The ring was then recycled through the furnace. This cycle was at a higher temperature than would be required for stress relieving in order to creep form the ring back to shape and thereby removing the buckles. After this second heat cycle, the ring was machined to shape within drawing tolerance. This welding and machining task considering size, thickness and final tolerances may be a near first in titanium fabrication.

After the machining the interface holes of this ring with other major equipment elements of the telescope vehicle were drilled 1/8 inch undersize.

### 3.3 Fasteners

The fasteners consisted of the bolts and nuts connecting the two rings forming the Transition Ring Assembly and the bolts and nuts connecting this assembly with other major elements of the telescope vehicle. There were several hundred 1/2 and 3/4 inch diameter bolts of various lengths to fit the various thickness of metal. The bolts and nuts obtained were 220,000 PSI high strength twelve point external wrenching (BAC Standard Part No. B30MT and N10HR). Nut retainers of SPS 6600E WHT and associated nuts of SPS 42FW (180,000 PSI) were selected for four inaccessible areas.

The bolts and nuts selected were Company stock items primarily used in the commercial airplane programs. The anchor nut retainers and associated nuts were purchased items from the Standard Pressed Steel Company of Santa Ana, California. All fasteners when obtained were cadmium plated which is not acceptable for space application. The fasteners were deplated and a dry lubrication applied.

### 3.4 Assembly (GE 1297296, GE 1297297, GE 1297298)

This task involved drilling of all mating holes in the two rings in the assembled condition. After the holes were drilled, the two ring structures without bolts were weighed. The combined weight of the two rings was 2,040 pounds. It was determined during the assembly operation that the edge of all holes mated with the bolt holes had to be chamfered. The bolts have a fillet radius where the head joins the shank. In this application where washers are not to be used this fillet radius prevents the head of the bolt from fitting flush with the ring surface unless a chamfer is made.

### 3.5 Hole Transfer Templates

Templates were fabricated to provide interface hole locations on the Primary Mirror Support Structure, Radial and On-Axis Instrument Structure and Spacecraft Structure with the Transition Ring Assembly. These templates were made from mild steel 1/4 inch tooling stock plate material. The holes in these templates were drilled simultaneously when the holes in the two rings were made.

### 3.6 Packaging/Shipment

This task included the design and fabrication of a shipping container for shipping the ring assembly from Boeing-Seattle to Goddard at Greenbelt, Maryland. The container was designed for highway motor transportation using a depressed bed trailer because of the size of the ring assembly. The design of the container placed the ring at a 45° angle so as to fit the height limitation of the truck. The container design was approved by Mr. C. C. Castro, NASA Traffic Manager, at Goddard. After the container was fabricated the ring assembly, templates and separately packaged bolts were crated and then shipped.

## 4.0 Project Time History

The actual calendar time for accomplishing the previously described task is shown on page 10. Hardware delivery and reporting was accomplished within Goddard required time scales. The pacing task was the Transition Ring fabrication. Fifteen weeks were expended from the time the order was placed with subcontractor to the time the forging arrived in Seattle. Boeing

# PROJECT TIME HISTORY

CONTRACT SIGNATURE

▼ 6/10

TRANSITION RING

Forging Procurement

Fabrication

ADAPTER AND STAGING RING ( material procurement & fabrication )

FASTENERS ( procurement & deplating )

HOLE TRANSFER TEMPLATES ( material procurement & fabrication )

ASSEMBLY ( hole drilling & bolting )

PACKAGING & SHIPMENT

container design & fabrication

pack. &  
shipment

REPORTING TO GSFC

on-dock GSFC  
NOV. 23

bi - weekly

final

May

June

July

August

September

October

November

December

1971

\* Coddard Technical Acceptance Inspection

expended eight weeks in machining the forging. The total time for this task was 23 weeks. The assembly task took three weeks and therefore the total fabrication time for the Transition Ring was 26 weeks.

### 5.0 Conclusions

Three basic conclusions can be made from the experience gained in accomplishing this effort.

1. This work involved fabricating the largest titanium forging ever made, one of the most intricate machining efforts ever made on a piece of titanium of this size, and accomplishing one of the largest titanium hand weldments in manufacturing the flat ring.
2. The manufacturing experience gained from the development activity on the SST program did materially contribute to the successful accomplishment of the total task.
3. The total contract effort was successfully accomplished within the required time scale which, considering the many firsts, demonstrates that structural elements for the Large Space Telescope (LST) can in fact be manufactured in titanium and at a reasonable cost for the LST flight program.